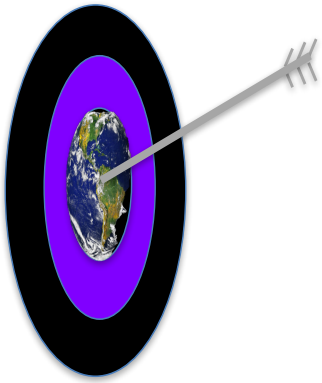


Updates to the VIIRS Dark Target Aerosol Retrieval

Virginia Sawyer, Robert Levy, Shana Mattoo, Geoff Cureton, and Yingxi Shi

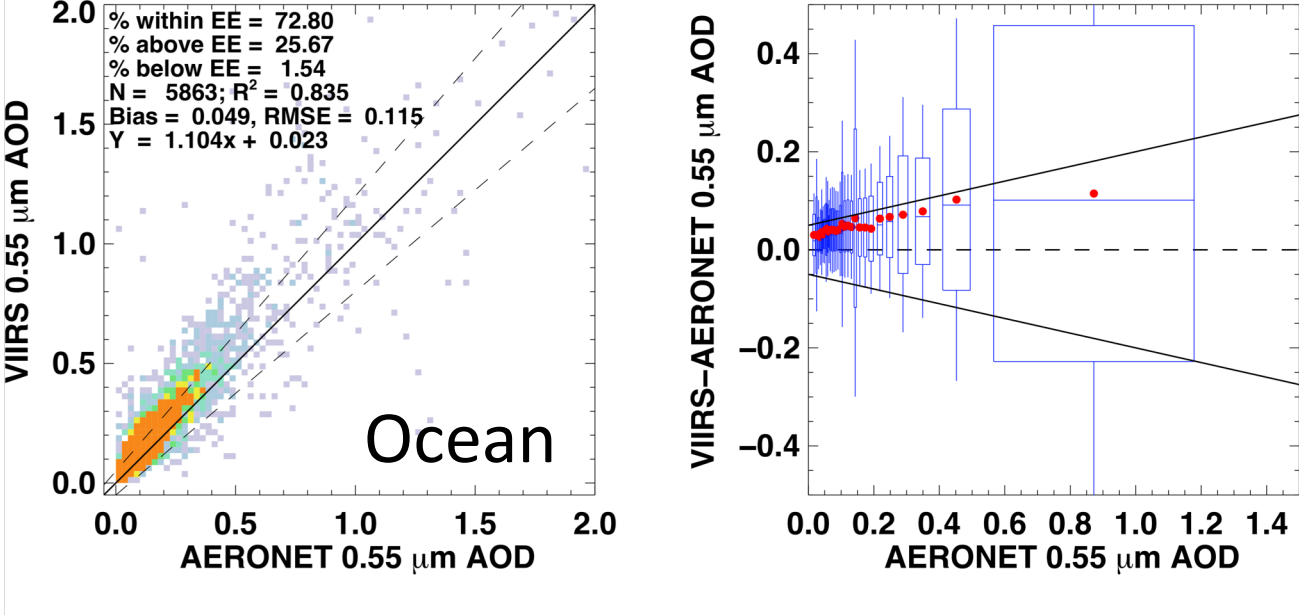
What Is VIIRS Dark Target?

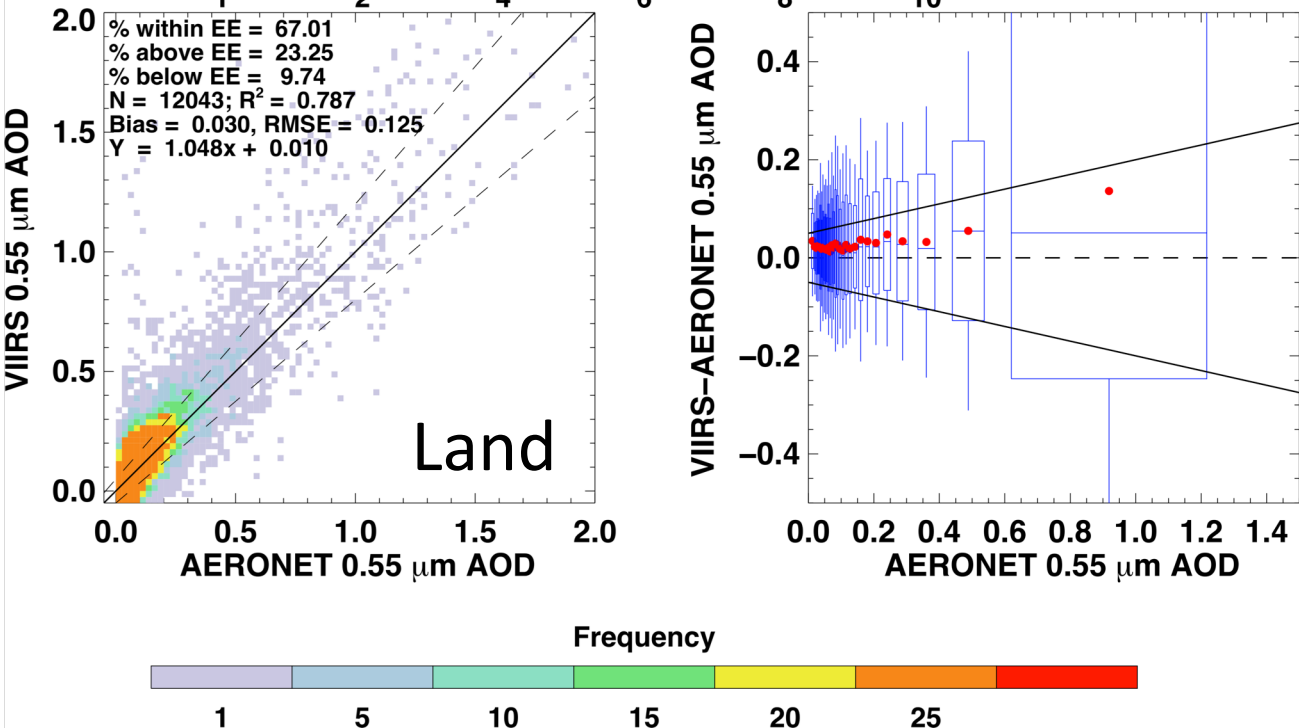
- “Dark Target” retrieves aerosol optical depth by contrasting aerosol with a darker ocean or vegetated surface
- Ported to VIIRS with as close as possible to the same algorithm as the MODIS Dark Target product
- Provides continuity between the Terra/Aqua AOD record (early 2000s to mid-2020s) and Suomi-NPP (2012 onward), with future support for NOAA-20 and upcoming JPSS

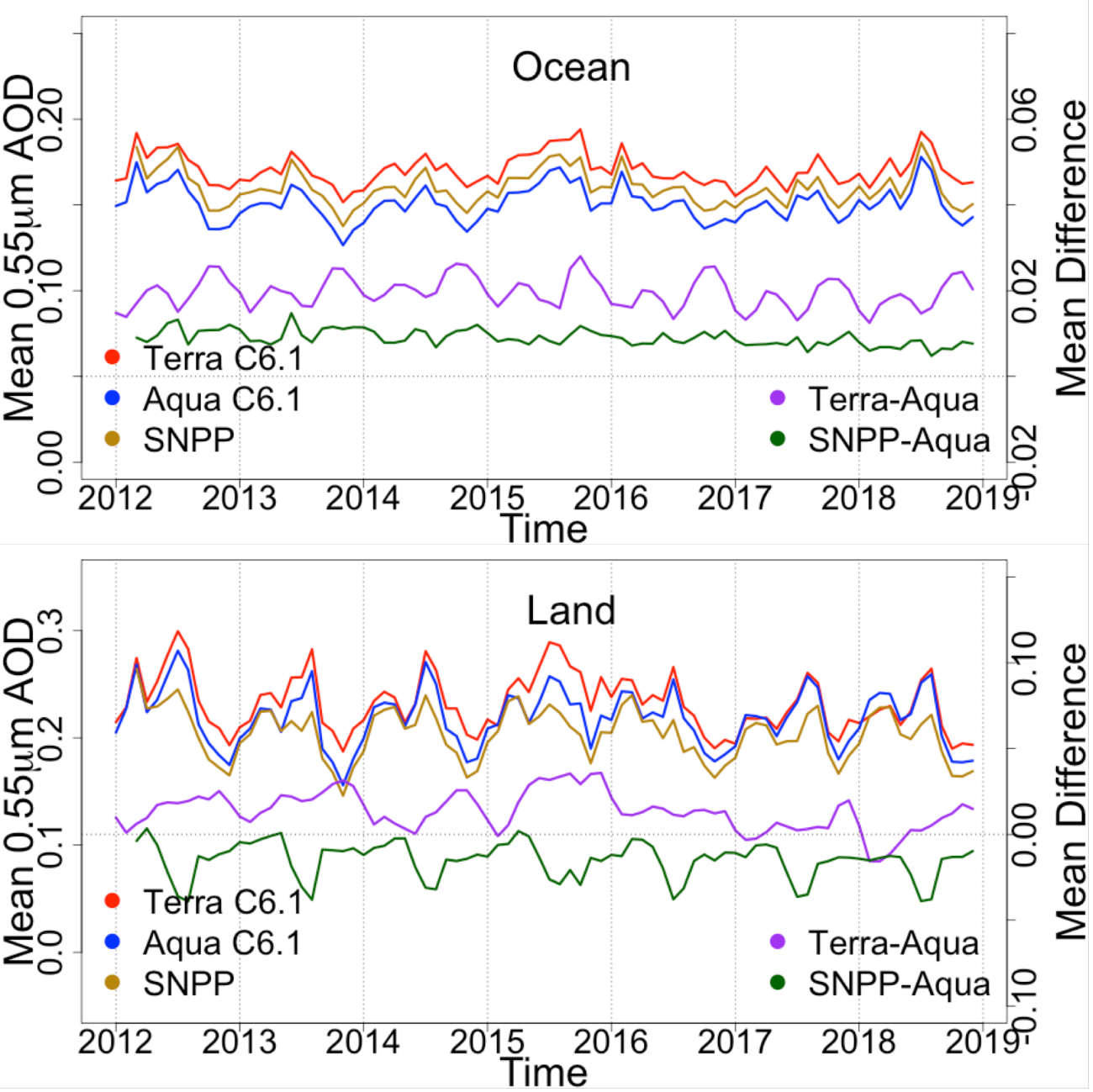
Key Product Differences

Product Features	Aqua-MODIS (MYD04_L2)	SNPP-VIIRS (AERDT_L2_VIIRS_SNPP)
Nadir resolution	10 km	6 km
Ancillary cloud mask	Wisconsin Cloud Mask (MYD35_L2)	MODIS-VIIRS Continuity Cloud Mask (CLDMSK_L2_VIIRS_SNPP)
File format	HDF4	netCDF-4
Typical granule size	5 minutes; 203x135 pixels	6 minutes; 404x400 pixels

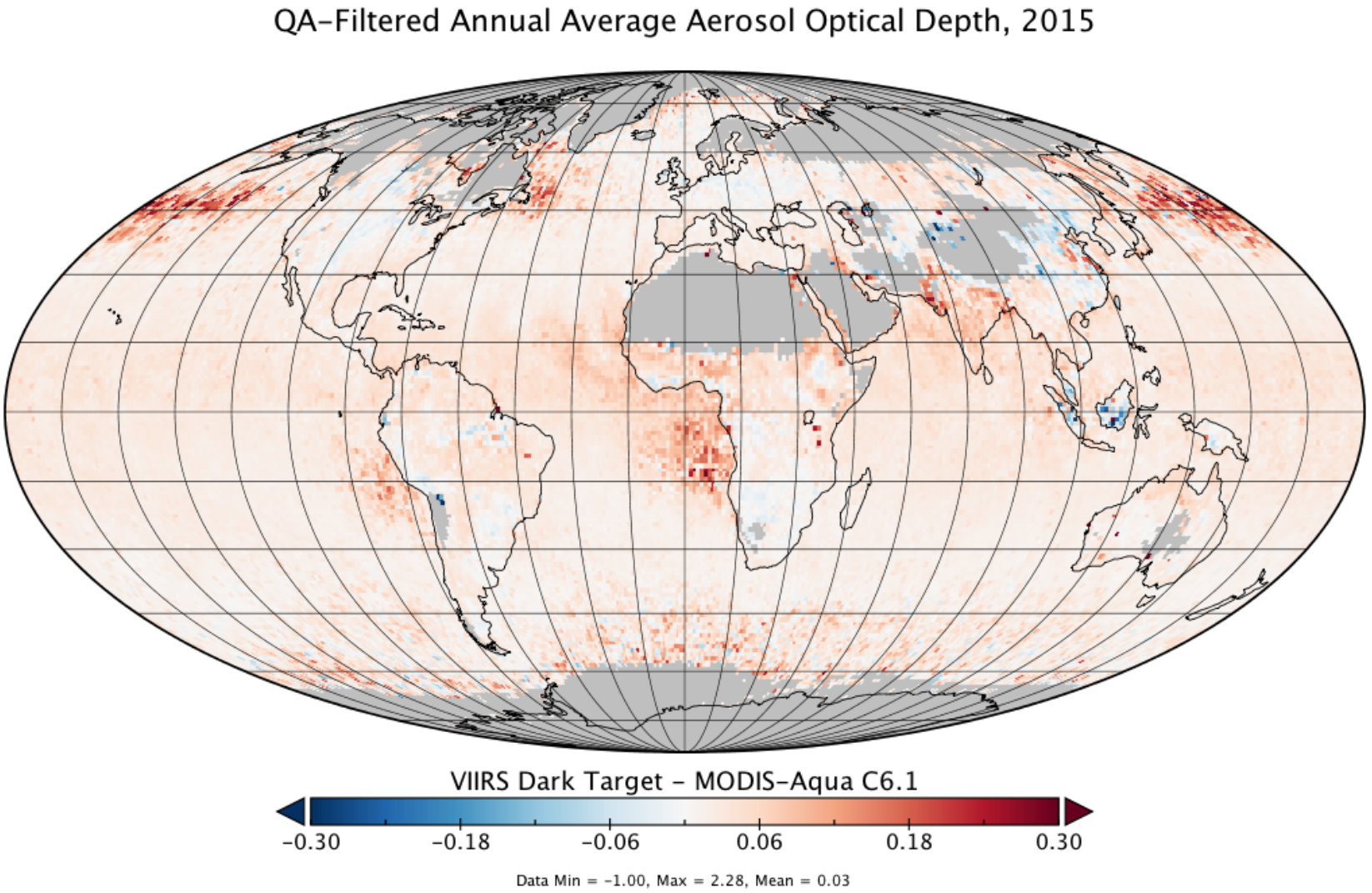
AERONET vs. collocated VIIRS SNPP Dark Target 0.55 μm AOD





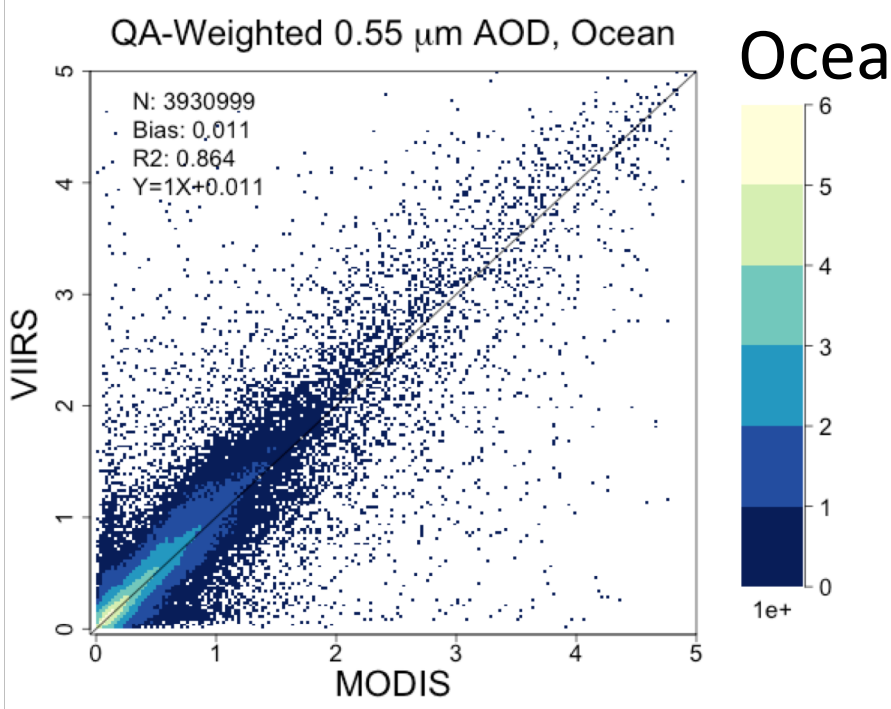


Area-weighted global average offsets between MODIS Terra, MODIS Aqua, and VIIRS SNPP

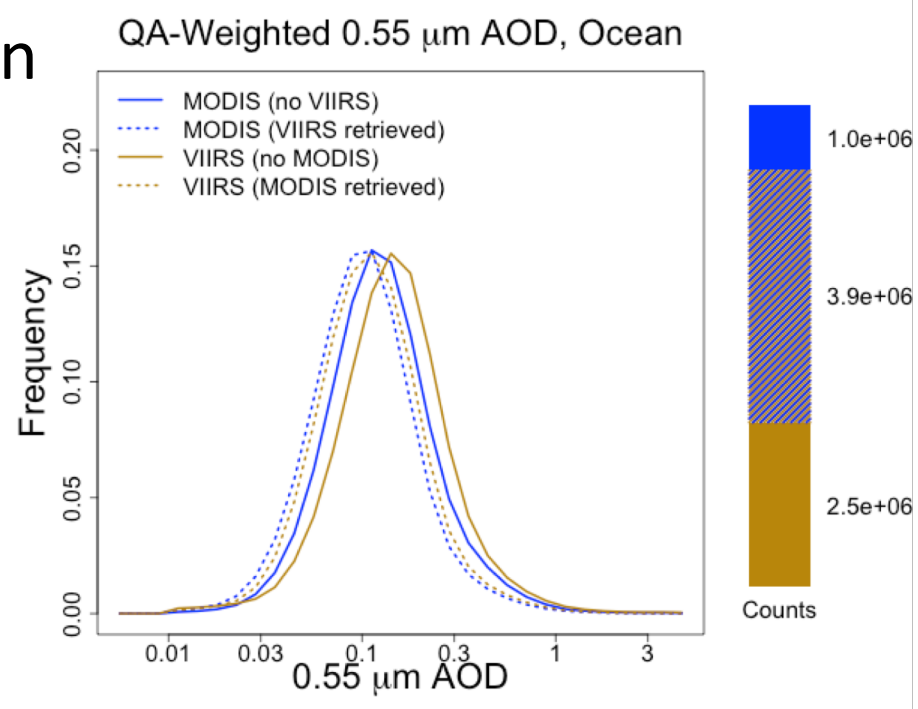


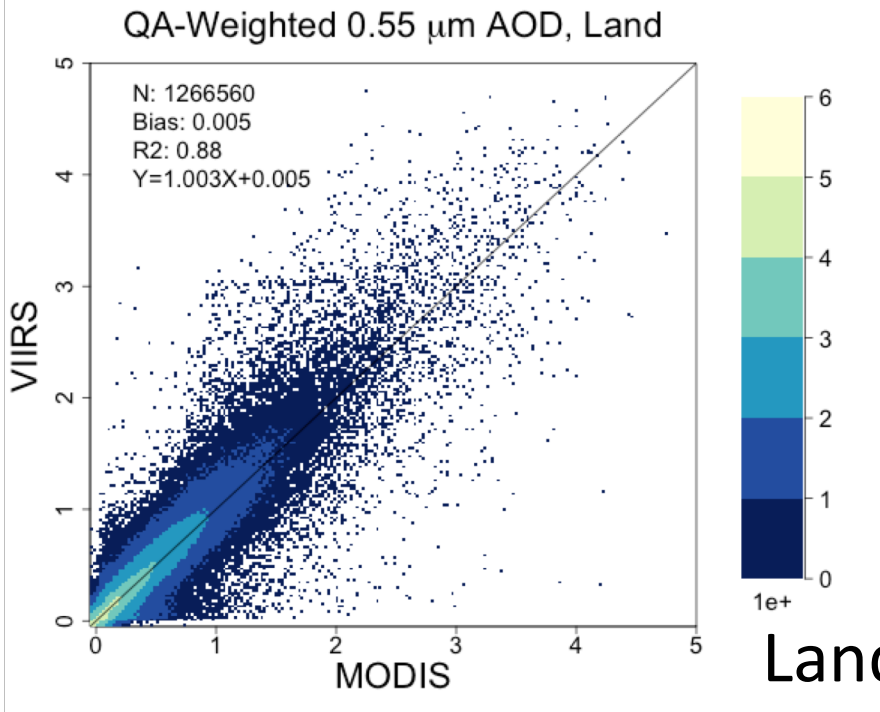
Overall positive offset over ocean comes from calibration differences between VIIRS SNPP and MODIS Aqua

Regional offsets can reflect seasonal aerosol, storm tracks

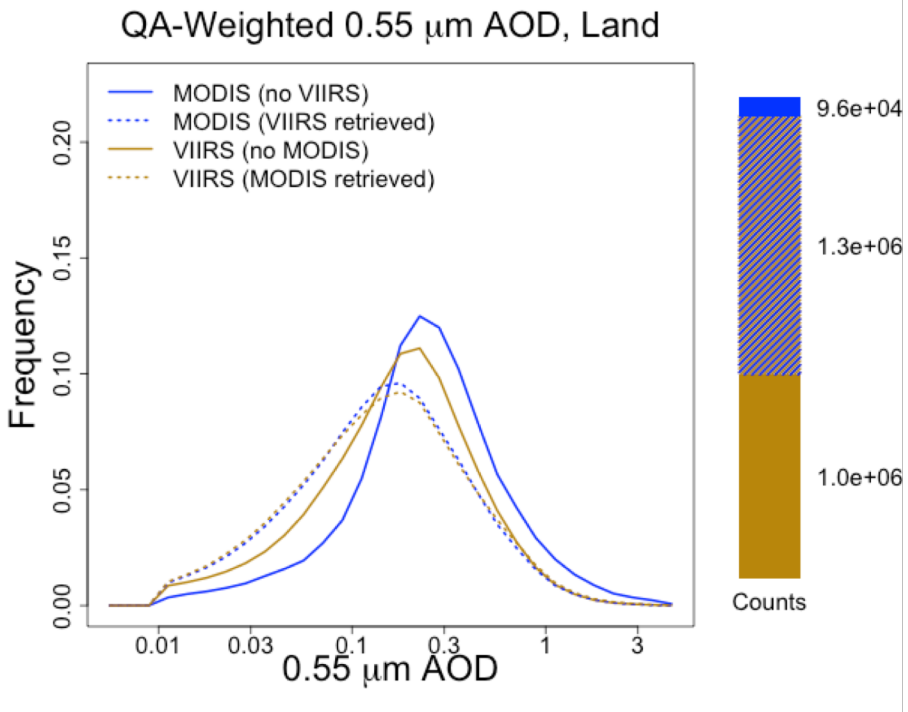

QA-Weighted 0.55 μm AOD, Ocean
N: 3930999
Bias: 0.011
R2: 0.864
Y=1X+0.011
VIIRS
MODIS
1e+

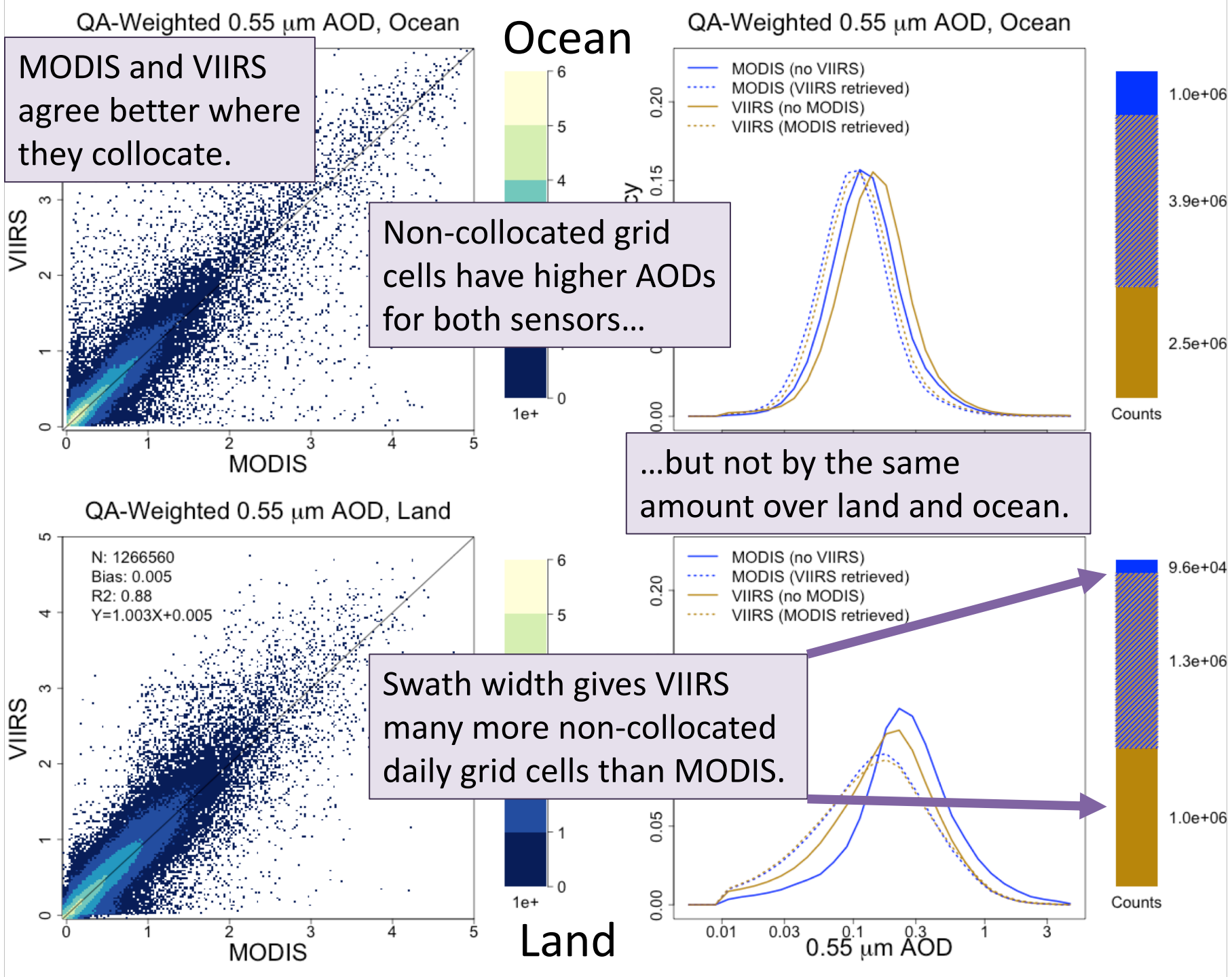
Ocean


QA-Weighted 0.55 μm AOD, Ocean
MODIS (no VIIRS)
MODIS (VIIRS retrieved)
VIIRS (no MODIS)
VIIRS (MODIS retrieved)
Frequency
0.55 μm AOD
1.0e+06
3.9e+06
2.5e+06
Counts


QA-Weighted 0.55 μm AOD, Land
N: 1266560
Bias: 0.005
R2: 0.88
Y=1.003X+0.005
VIIRS
MODIS
1e+

Land

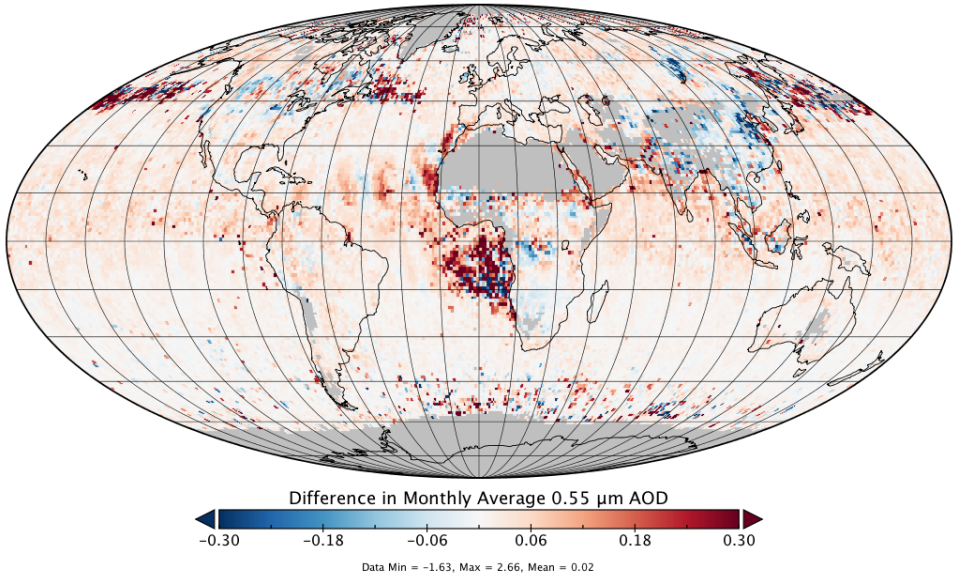

QA-Weighted 0.55 μm AOD, Land
MODIS (no VIIRS)
MODIS (VIIRS retrieved)
VIIRS (no MODIS)
VIIRS (MODIS retrieved)
Frequency
0.55 μm AOD
9.6e+04
1.3e+06
1.0e+06
Counts


QA-Weighted 0.55 μm AOD, Ocean
Ocean
MODIS and VIIRS agree better where they collocate.
VIIRS
MODIS
Non-collocated grid cells have higher AODs for both sensors…
QA-Weighted 0.55 μm AOD, Ocean
MODIS (no VIIRS)
MODIS (VIIRS retrieved)
VIIRS (no MODIS)
VIIRS (MODIS retrieved)
1.0e+06
3.9e+06
2.5e+06
Counts
…but not by the same amount over land and ocean.
QA-Weighted 0.55 μm AOD, Land
N: 1266560
Bias: 0.005
R2: 0.88
Y=1.003X+0.005
Swath width gives VIIRS many more non-collocated daily grid cells than MODIS.
9.6e+04
1.3e+06
1.0e+06
0.55 μm AOD
Land

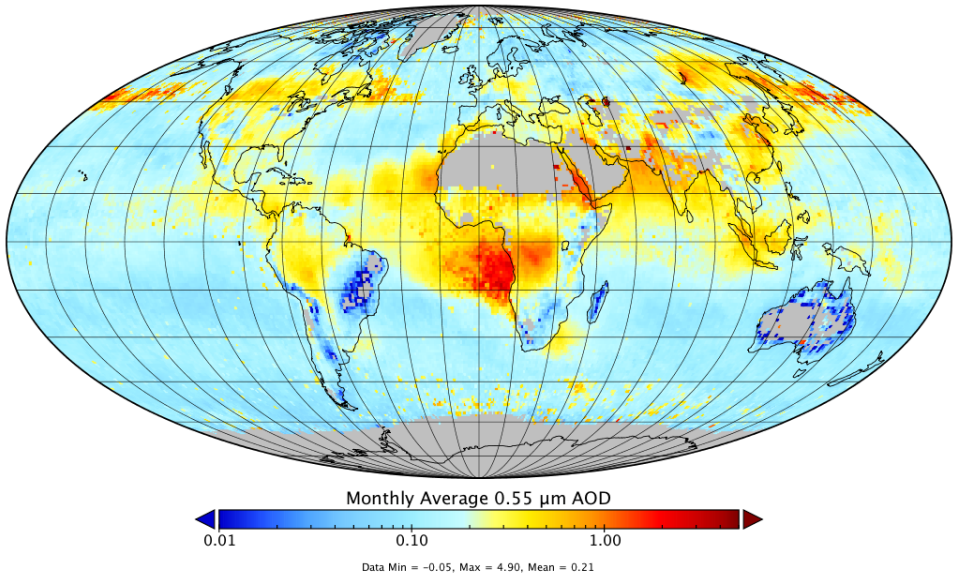
August over land has the greatest negative offset in AOD for 2015

Cloud cover drives many areas of low retrievability (percentage of all L2 pixels in the grid cell that have valid DT retrievals) and of greater offset between VIIRS and MODIS

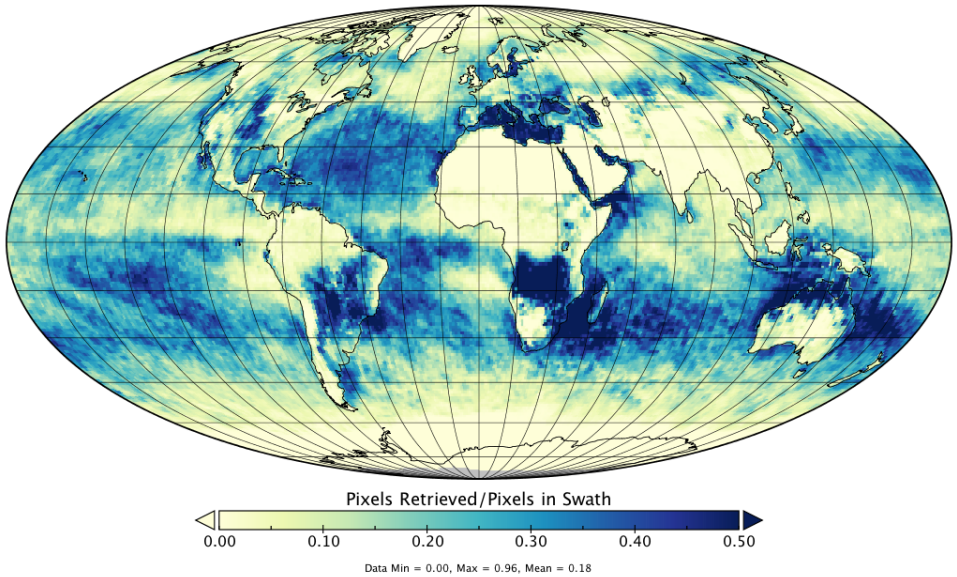
VIIRS - MODIS AOD

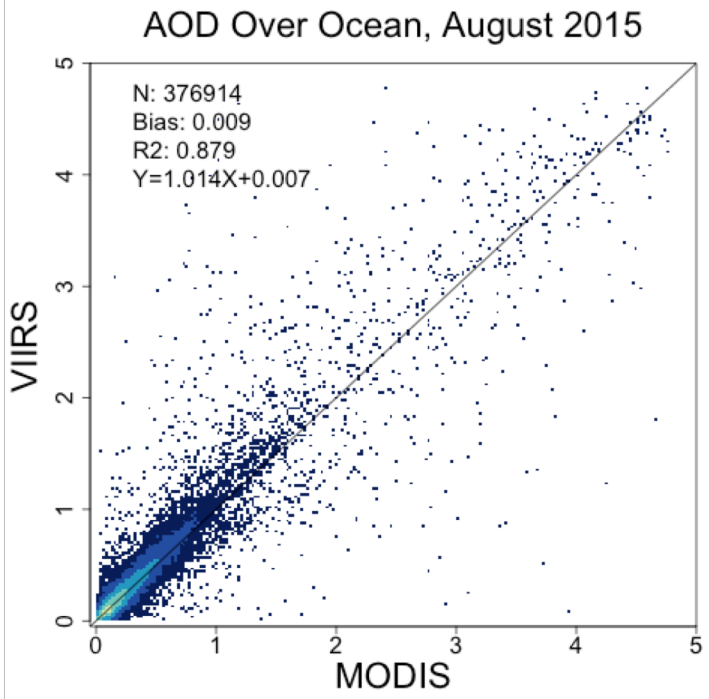


VIIRS AOD, August 2015

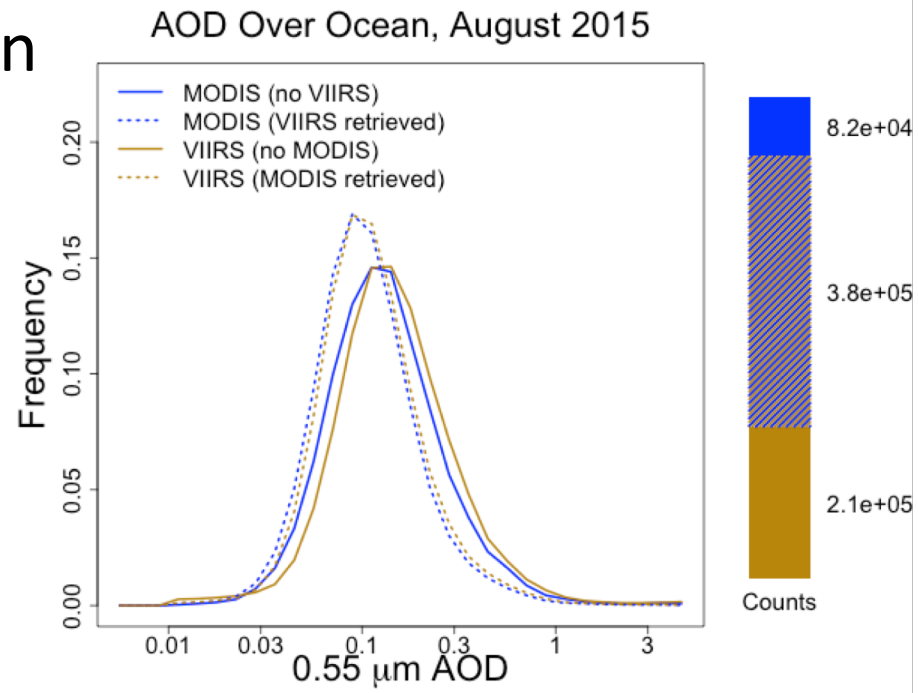


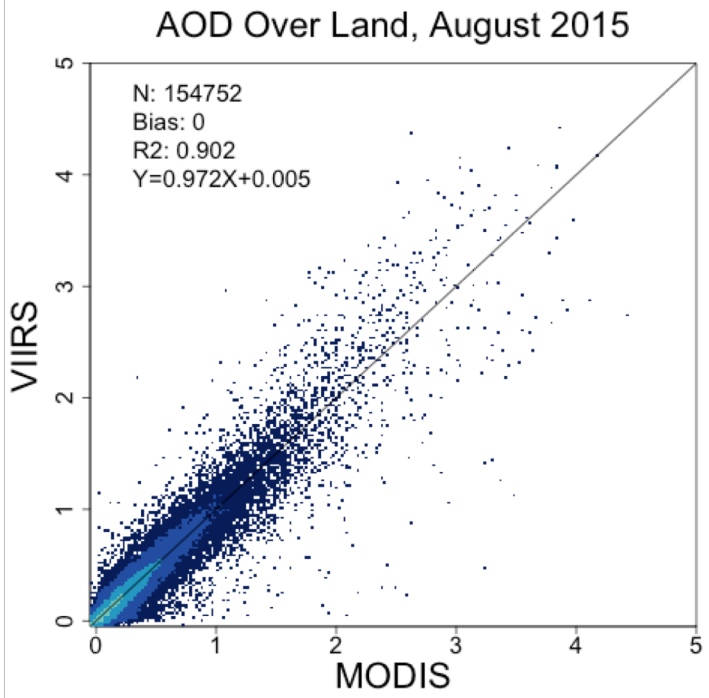
VIIRS Retrievability



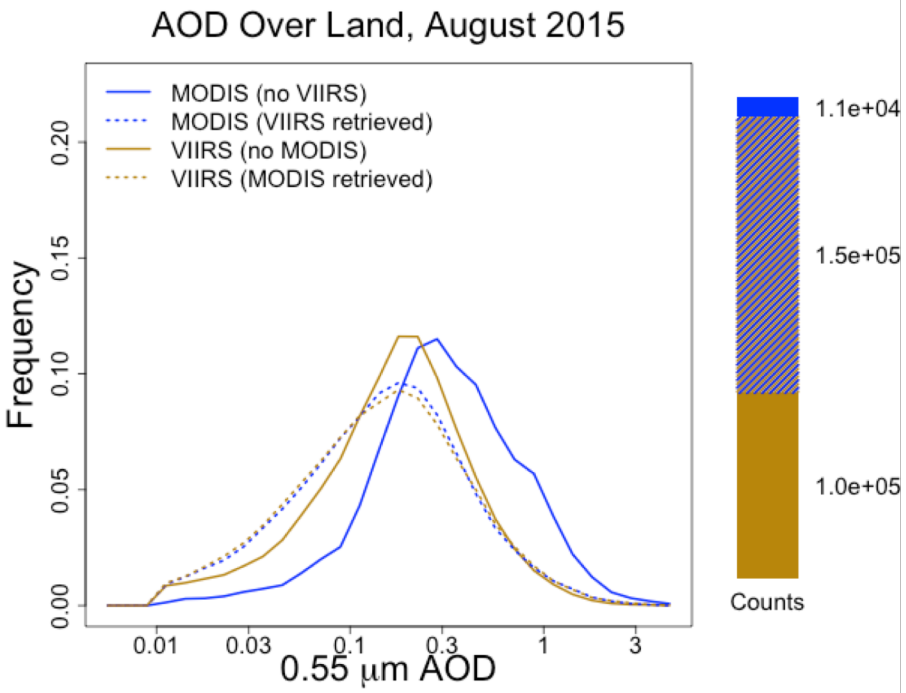

AOD Over Ocean, August 2015
N: 376914
Bias: 0.009
R2: 0.879
Y=1.014X+0.007
VIIRS
MODIS
0
1
2
3
4
5
1e+

Ocean


AOD Over Ocean, August 2015
MODIS (no VIIRS)
MODIS (VIIRS retrieved)
VIIRS (no MODIS)
VIIRS (MODIS retrieved)
Frequency
0.00
0.05
0.10
0.15
0.20
0.01
0.03
0.1
0.3
1
3
0.55 μm AOD
8.2e+04
3.8e+05
2.1e+05
Counts


AOD Over Land, August 2015
N: 154752
Bias: 0
R2: 0.902
Y=0.972X+0.005
VIIRS
MODIS
0
1
2
3
4
5
1e+

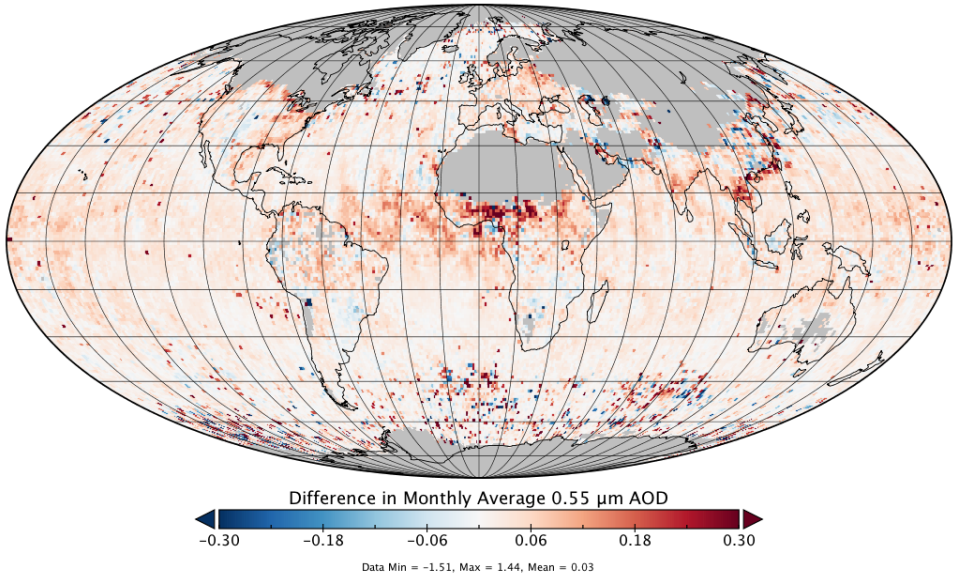
Land


AOD Over Land, August 2015
MODIS (no VIIRS)
MODIS (VIIRS retrieved)
VIIRS (no MODIS)
VIIRS (MODIS retrieved)
Frequency
0.00
0.05
0.10
0.15
0.20
0.01
0.03
0.1
0.3
1
3
0.55 μm AOD
1.1e+04
1.5e+05
1.0e+05
Counts

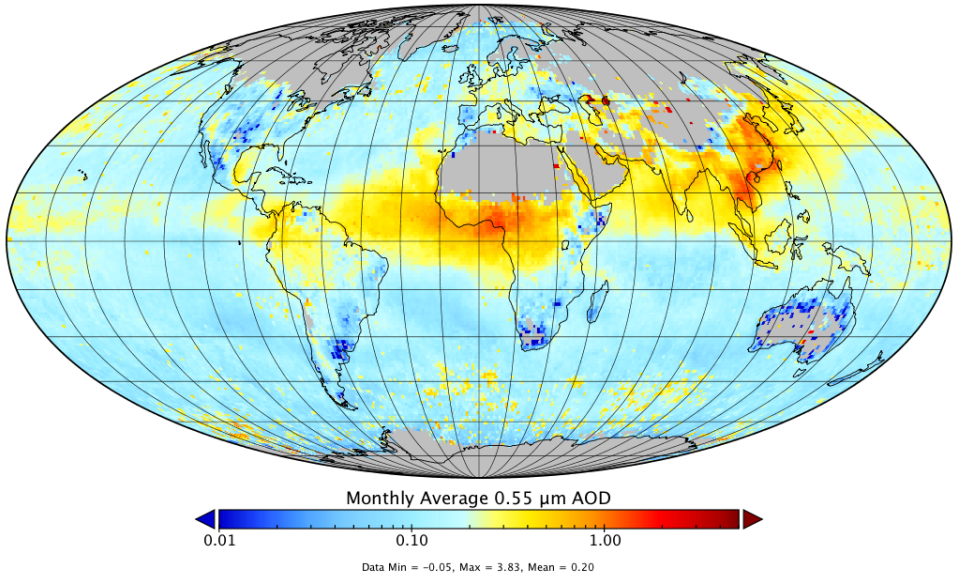
March over land has the smallest offset in AOD for 2015

Snow cover reduces sample size over land, but there are fewer sources of regional disagreement than in August

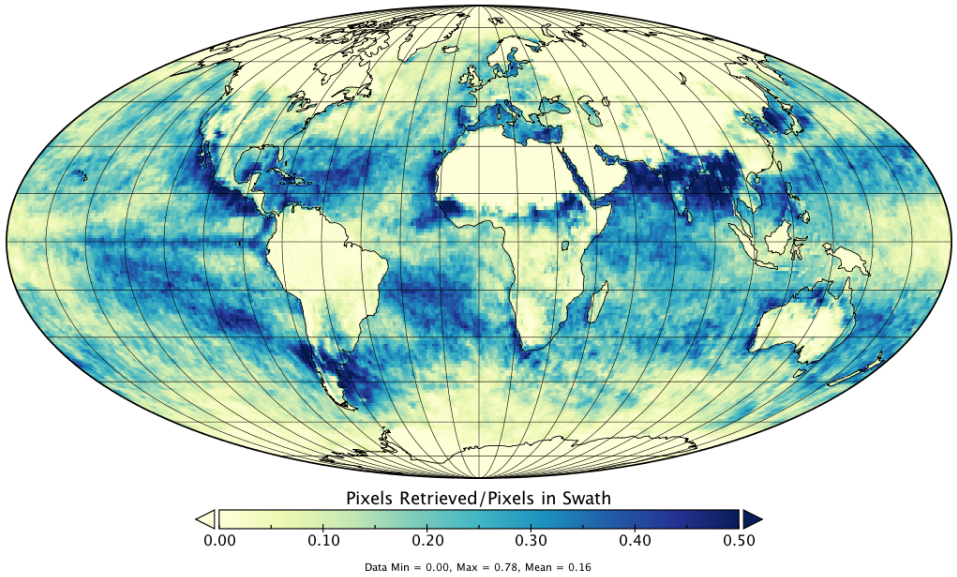
VIIRS – MODIS AOD

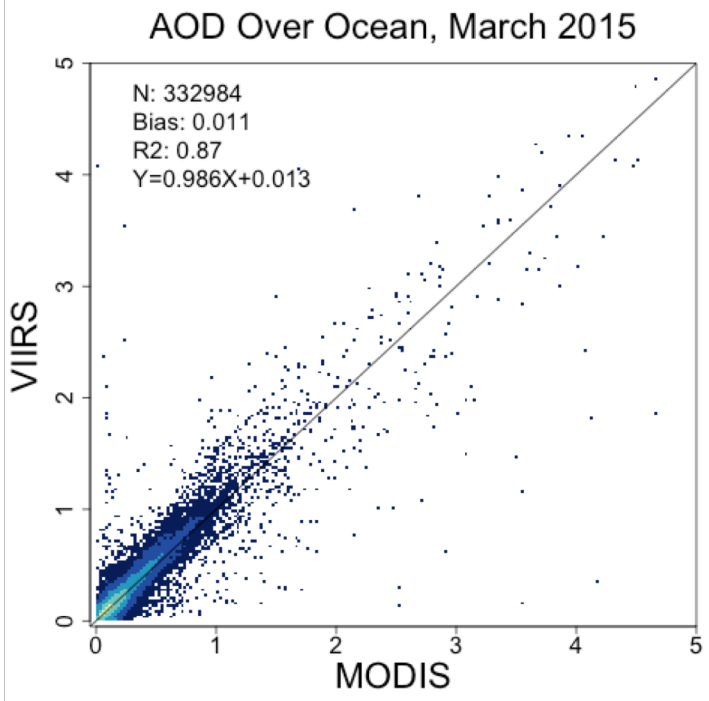


VIIRS AOD, March 2015

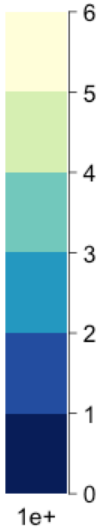


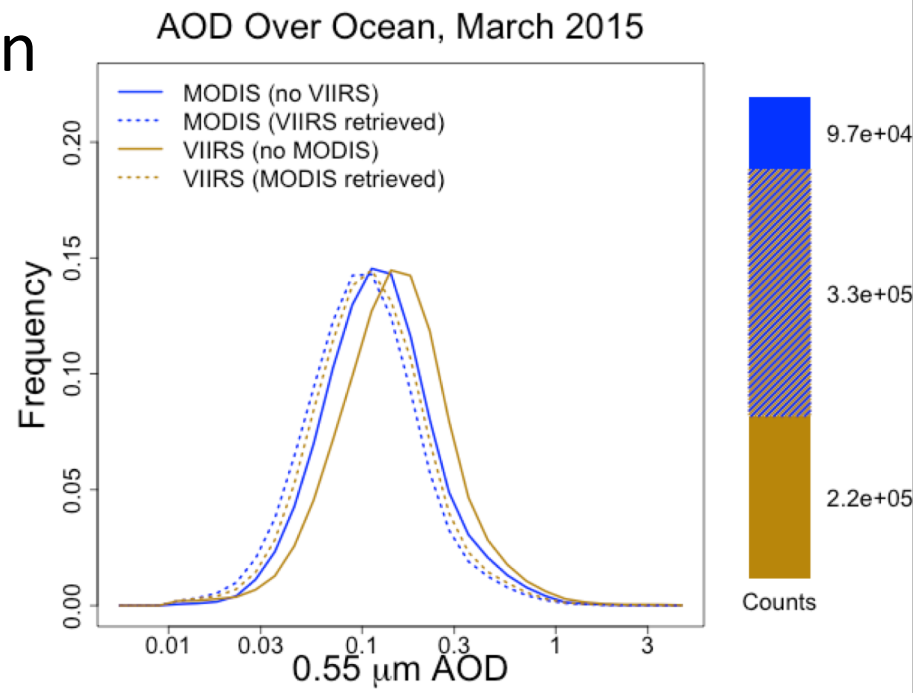
VIIRS Retrievability

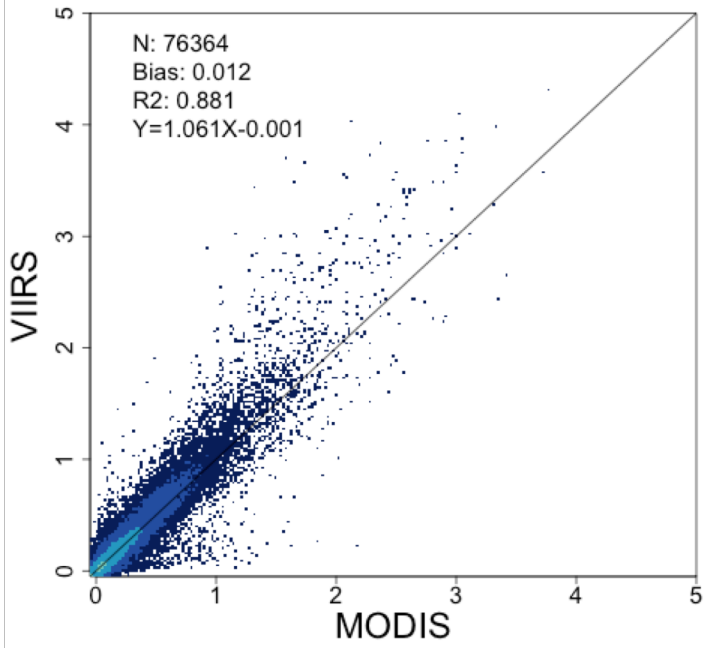


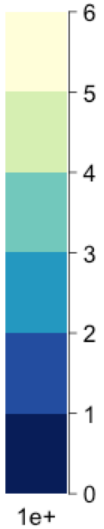

AOD Over Ocean, March 2015
N: 332984
Bias: 0.011
R2: 0.87
Y=0.986X+0.013
VIIRS
MODIS
0
1
2
3
4
5

Ocean

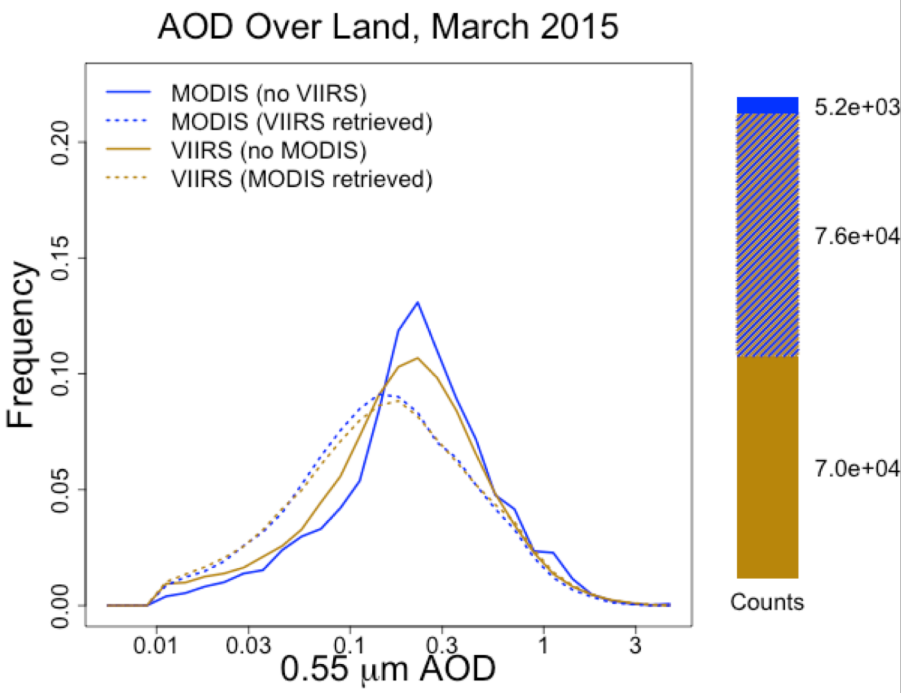

0
1
2
3
4
5
6
1e+


AOD Over Ocean, March 2015
MODIS (no VIIRS)
MODIS (VIIRS retrieved)
VIIRS (no MODIS)
VIIRS (MODIS retrieved)
Frequency
0.55 μm AOD
0.01
0.03
0.1
0.3
1
3
9.7e+04
3.3e+05
2.2e+05
Counts


AOD Over Land, March 2015
N: 76364
Bias: 0.012
R2: 0.881
Y=1.061X-0.001
VIIRS
MODIS
0
1
2
3
4
5


0
1
2
3
4
5
6
1e+

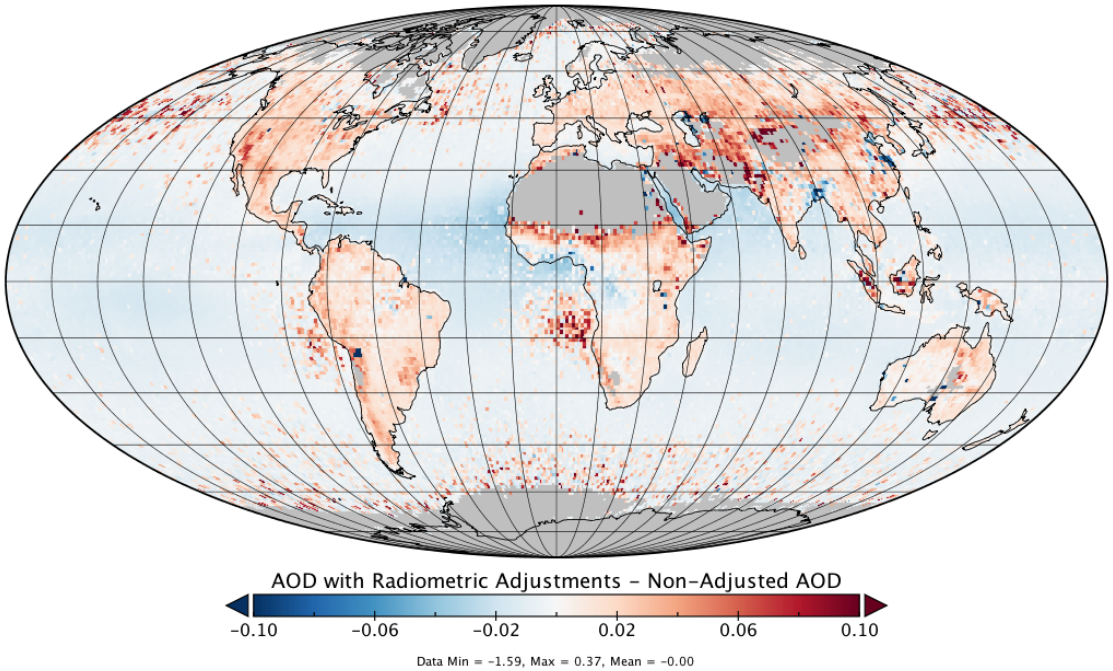
Land


AOD Over Land, March 2015
MODIS (no VIIRS)
MODIS (VIIRS retrieved)
VIIRS (no MODIS)
VIIRS (MODIS retrieved)
Frequency
0.55 μm AOD
0.01
0.03
0.1
0.3
1
3
5.2e+03
7.6e+04
7.0e+04
Counts

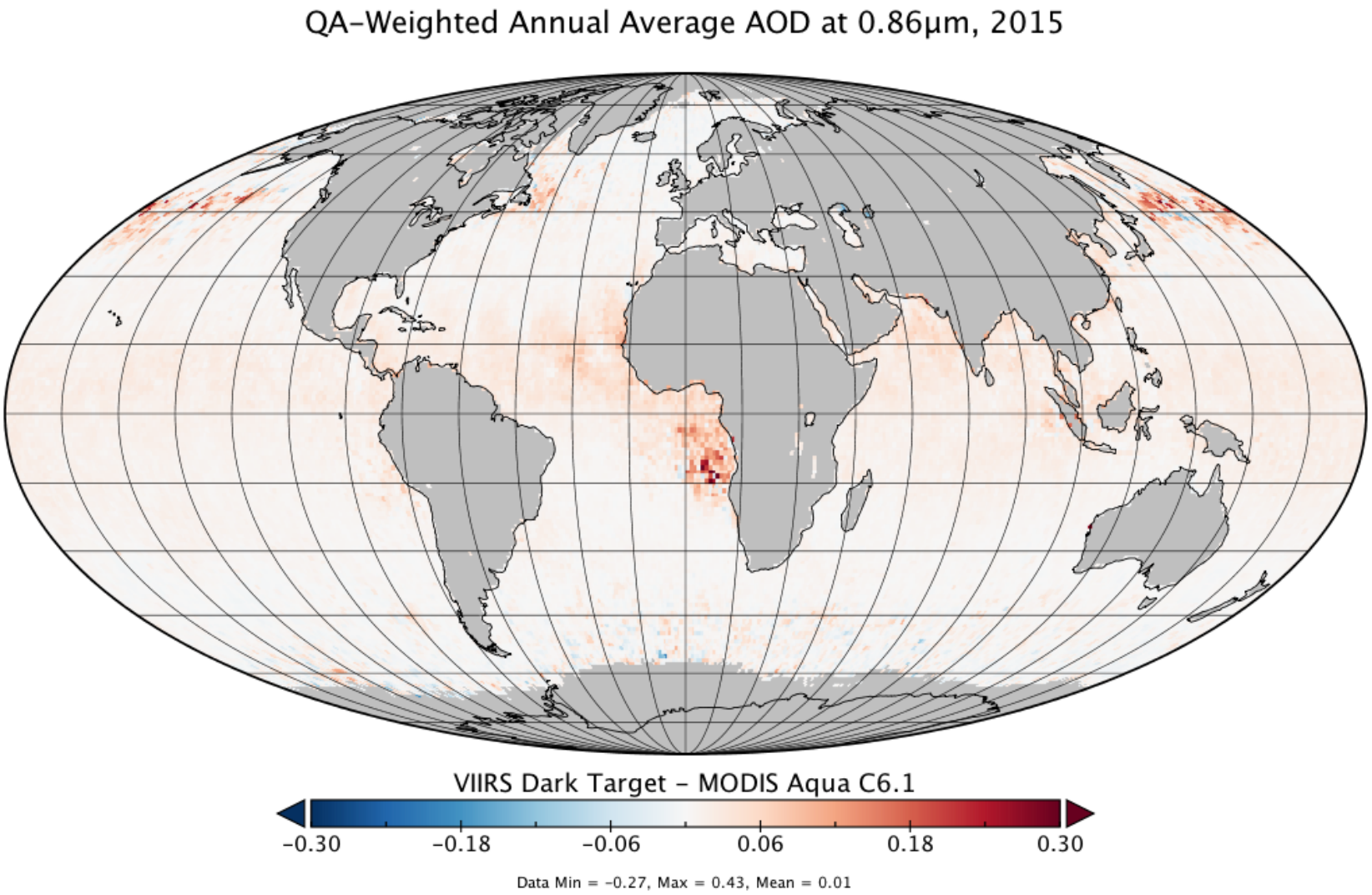
Radiometric adjustment (Sayer et al. 2016) reduces offsets by bringing VIIRS L1b reflectances closer to MODIS

Practical disadvantages to making this a permanent part of VIIRS DT: what about future launches?

AOD Difference with Radiometric Adjustments

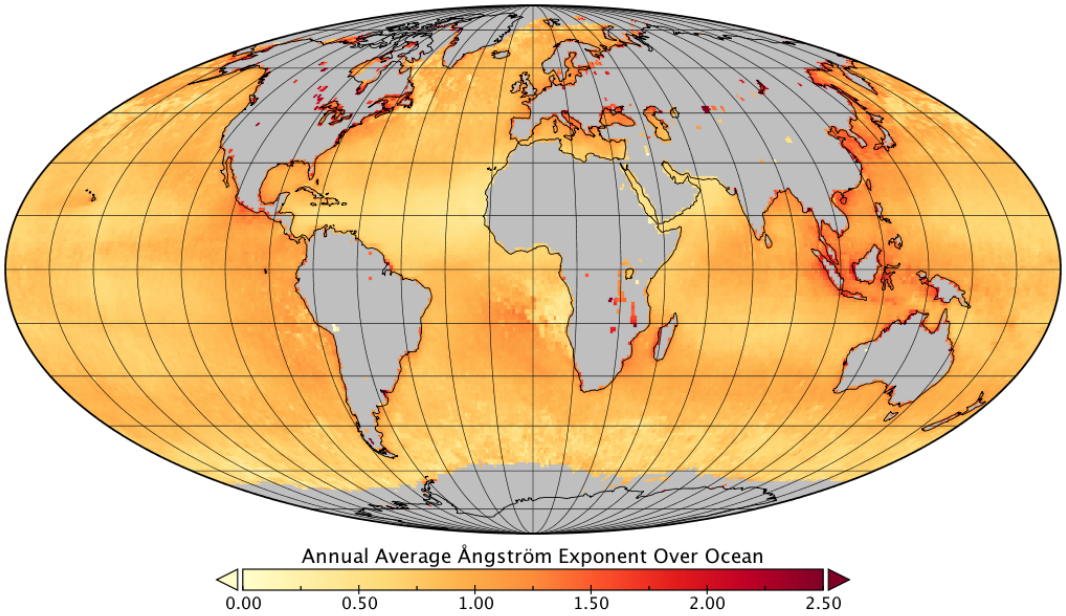


VIIRS Band	Wavelength (µm)	Adjustment Factor
M3	0.49	0.990
M4	0.55	0.956
M5	0.67	0.937
M7	0.86	0.962
M8	1.24	1.021
M10	1.60	0.980
M11	2.26	0.933

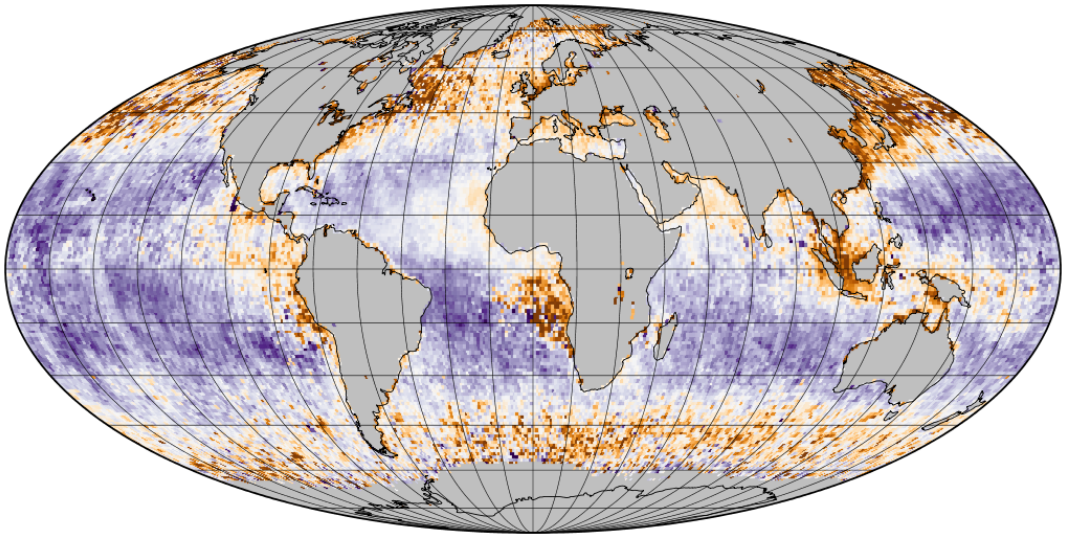


Annual average disagreement between VIIRS SNPP and MODIS Aqua AOD is smaller at 0.86 µm than at 0.55 µm because of smaller calibration difference, but this magnifies disagreement in ratio between the two bands

VIIRS Ångström Exponent, 2015



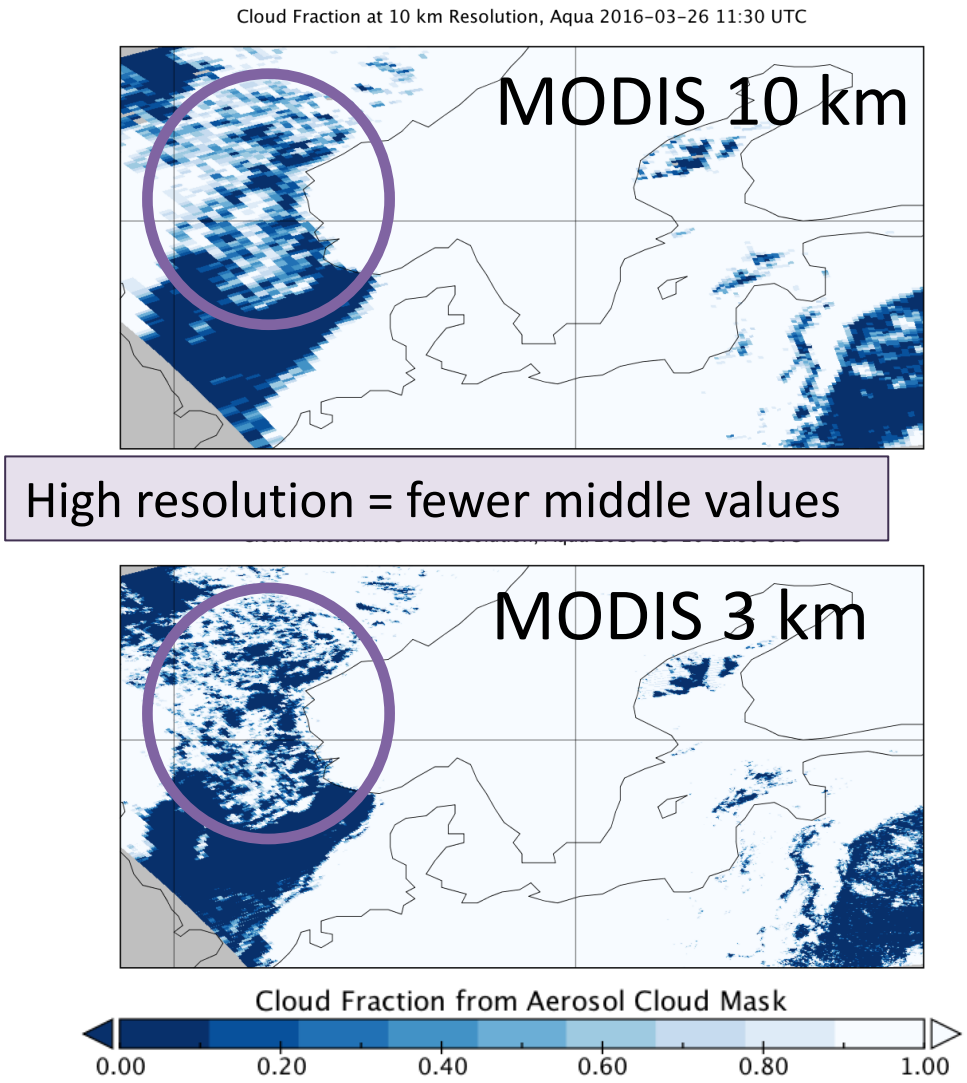
VIIRS - MODIS Ångström Exponent, 2015



Disagreement between VIIRS SNPP and MODIS Aqua is greater for Ångström exponent than for AOD

Regions with higher cloud coverage tend to indicate larger particle sizes than MODIS, while overall offset over ocean indicates smaller particles

Cloud Fraction and Resolution



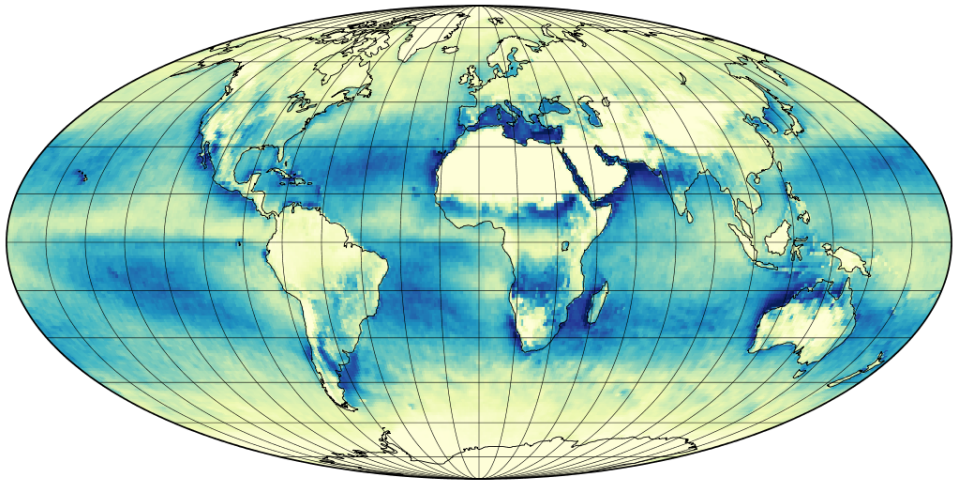
Using the same cloud masking process, higher resolution data considers more area to be either completely clear or completely overcast

DT retrieves from partly cloudy pixels but not from overcast, so resolution affects sampling

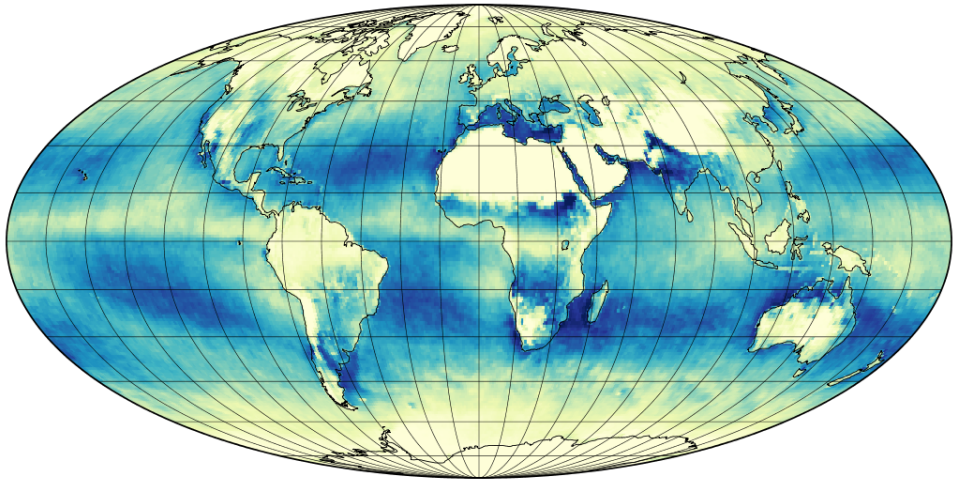
At 6 km nadir resolution, VIIRS DT has AOD retrievability between the MODIS 10 km and 3 km products

VIIRS retrieves a smaller fraction of pixels from a wider swath than MODIS 10 km

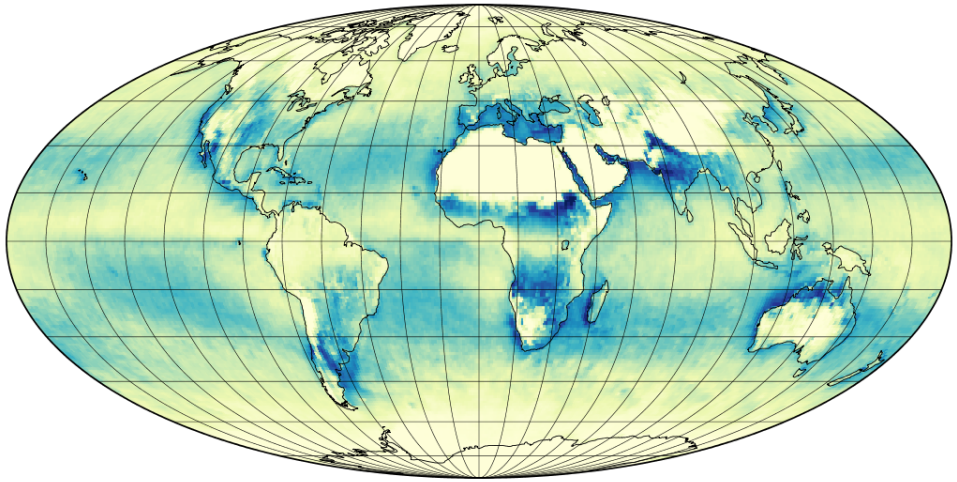
VIIRS AOD Retrievability, Mean=**0.16**



MODIS 10 km AOD Retrievability, Mean=**0.18**



MODIS 3 km AOD Retrievability, Mean=**0.12**

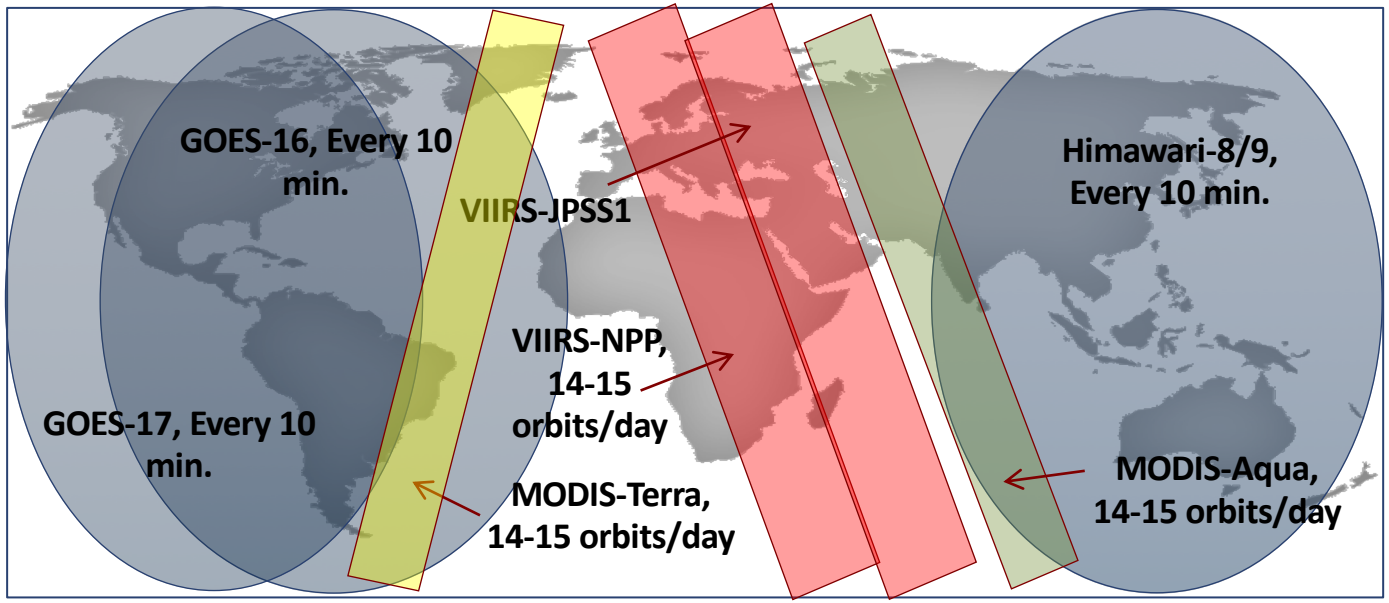


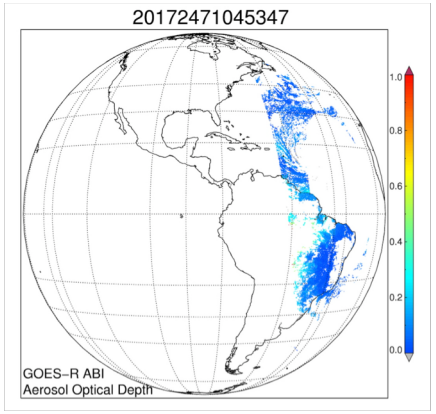
Summary

- VIIRS Dark Target retrieves AOD with comparable skill to MODIS version, albeit with persistent offsets
- Causes for disagreement include
  - Instrument calibration
  - Sampling due to cloud masking, product resolution
  - Non-collocated retrievals with AOD distribution that differs from collocated AOD distribution
- MODIS and VIIRS detect the same regional and seasonally varying aerosol events, but often sample them differently and disagree in the details
- Calibration offsets differ by wavelength, which affects Ångström exponent

Temporal View of Aerosols: GEO & LEO Integration

A MEaSUREs Project: PI – Rob Levy





Gupta et al., 2019

(https://doi.org/10.5194/amt-2019-65)

Data gaps by geostationary observation in the part of the world will be filled with multiple LEO observations until Meteosat Third Generation Satellites (FCI) become available. Aerosols data from all five sensors will be processed with the same DT algorithm

Data Product Status

- AERDT_L2_VIIRS_SNPP is moving to forward processing on SIPS
- LAADS hosting to follow
- Level 3 gridded daily and monthly average products will follow SIPS format convention, and may use different gridding logic from MODIS
- Previous stable version 1.0dev4 is run from the beginning of the VIIRS SNPP mission through January 2019
- Contact virginia.r.sawyer@nasa.gov for data access